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Single Port Retroperitoneoscopic Adrenalectomy in Dogs : An Experimental Study

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Single Port Retroperitoneoscopic Adrenalectomy in Dogs : An Experimental Study

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Abstract

Laparoscopic adrenalectomy is a minimally invasive surgery that is becoming an alternative to conventional veterinary surgery. In human medicine, because adrenal glands are in retroperitoneum,

retroperitoneoscopic adrenalectomy was devised in order to reduce surgical time. This study is to devise a retroperitoneoscopic adrenalectomy procedure and evaluate the feasibility of single port retroperitoneoscopic adrenalectomy (SPRA) in dogs. SPRA was performed on the left side and right side in 4 dogs, respectively. Resection of the adrenal gland was implemented using LigaSure and Kelly laparoscopic forceps through a SILS (Single Incision Laparoscopic Surgery) port via a 3-cm incision using a retroperitoneal approach. Postoperative pain was evaluated using the Numerical Rating Scale, University of Melbourne Pain Scale, and Colorado State University Veterinary Medical Center Canine Acute Pain Scale. Surgical injury to the adrenal gland capsule was evaluated by histologic assessment. Upon approaching the retroperitoneal space, the adrenal gland was visualized directly regardless of direction after dissecting the fatty tissues. The mean time taken to complete the SPRA was 44.1 (range 37–51) min, and was significantly longer on the right (49.3 min) than on the left (38.5 min) ($P < .05$) There were no complications intraoperatively or during 14 days of postoperative monitoring. Postoperative pain was controlled by appropriate analgesia. The adrenal gland capsule was found to be injured in 3 (36%) of the 8 dogs on histologic assessment. Using this technique, it is possible to perform adrenalectomy without retracting other abdominal organs and gain direct access to the adrenal glands with excellent visibility.

Keyword : canine, retroperitoneoscopy, adrenalectomy, retroperitoneoscopic adrenalectomy, single port laparoscopy, minimally invasive surgery

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I. Introduction

Laparoscopic adrenalectomy is a minimally invasive surgery that is becoming an alternative to conventional veterinary surgery. (Mayhew *et al.*, 2014, Naan *et al.*, 2013, Jiménez *et al.*, 2008, Gasman *et al.*, 1998, Fransson and Mayhew, 2015) One study has reported that the median time taken to perform a laparoscopic adrenalectomy (90 min) was shorter than for open adrenalectomy (120 min). (Mayhew *et al.*, 2014) Moreover, there are some reports indicating that modified laparoscopic adrenalectomy in dogs has advantages when compared to laparoscopic adrenalectomy. (Naan *et al.*, 2013, Jiménez *et al.*, 2008) When laparoscopic adrenalectomy was performed in lateral recumbency, as described by Jiménez *et al.*, 2008, the surgery was feasible and without intraoperative complications. Laparoscopic adrenalectomy performed in sternal recumbency also has advantages, allowing gravitational displacement of the abdominal organs, better visualization of the adrenal gland, and a shorter surgical time than conventional laparoscopic or open adrenalectomy. The mean surgical time was reported to be 78.7 min. (Naan *et al.*, 2013) However, both methods require retraction of the abdominal organs. (Naan *et al.*, 2013, Jiménez *et al.*, 2008)

Meanwhile, in human medicine, operation times for laparoscopic adrenalectomy have not become shorter since the procedure was first performed in 1992. (Walz *et al.*, 2001) Retroperitoneoscopic adrenalectomy was devised in 1994 to address this issue. (Walz *et al.*,

2001, Walz *et al.*, 1996, Walz *et al.*, 1998, Heintz *et al.*, 1995) After standardization of the procedure, several studies reported that retroperitoneoscopic adrenalectomy had the advantages of a shorter operation time, less blood loss, and less pain when compared with transperitoneal laparoscopic adrenalectomy. (Walz *et al.*, 2001, Lee *et al.*, 2012) Recently, surgical procedures performed through a single port have become popular, affording better patient comfort, superior cosmetic results, less pain, and a more rapid functional recovery. (Gastellucci *et al.*, 2008, Freschi *et al.*, 2016, Karakuş *et al.*, 2016, Marks *et al.*, 2015) Single port retroperitoneoscopic adrenalectomy (SPRA) is an even more minimally invasive surgery, with the further advantages of single port access and being able to use a retroperitoneal approach. (Walz *et al.*, 2009, Walz *et al.*, 2010, Beiša *et al.*, 2012, Joseph and Patel, 2011, Beiša *et al.*, 2011)

However, the retroperitoneoscopic adrenalectomy in dogs has not been attempted except for adrenalectomy through retroperitoneal laparotomy (Johnston *et al.*, 1977) and is barely mentioned in the veterinary literature. (Fransson and Mayhew, 2015) In the previous study, the retroperitoneoscopic approach was viable and delivered good visualization. (Jeong *et al.*, 2016) In this regard, a single port retroperitoneal approach to adrenal gland resection has the possibility of

a better outcome than that achieved using several conventional surgical methods. In this study, I used a modified the posterior retroperitoneoscopic adrenalectomy technique developed for humans, (Callender *et al.*, 2009, Gockel *et al.*, 2005, Berber *et al.*, 2009) taking into account the differences between human and canine anatomy (Johnston *et al.*, 1990, Evans and de Lahunta, 2012) to improve the outcome of adrenalectomy in dogs. Assuming that SPRA could be performed in dogs, the objectives of this study were to determine if (1) retroperitoneal laparoscopy is a feasible approach for the adrenal gland, (2) the procedure is minimally invasive and offers direct access for excision of the adrenal gland, and (3) the adrenal glands can be manipulated directly without retraction of other organs.

II. Materials and methods

Eight healthy Beagle dogs (mean body weight 11.3 ± 1.0 kg, mean body condition score 5.2 ± 0.9) were allocated to undergo right-sided (n=4) or left-sided (n=4) adrenalectomy. All dogs were premedicated with acepromazine 0.01 mg/kg intravenously (IV), tramadol 5 mg/kg IV, meloxicam 0.2 mg/kg subcutaneously, and cefazolin 22 mg/kg IV. Alfaxalone 2 mg/kg IV was used for induction of anesthesia, which was maintained using inhalational isoflurane with 100% oxygen. All SPRA procedures was performed by one surgeon (JK). Operation time was defined as the time from skin incision to completion of skin suture. This study was approved by the Institutional Animal Care and Use Committee. (SNU-160516-5)

Single Port Retroperitoneoscopy

The dogs were positioned in sternal recumbency without abdominal support using 3 cushions and self-adhesive tape as described by Naan *et al.*, 2013. The lateral aspect of the hemithorax and hemiabdomen was clipped from the level of the 11th thoracic vertebra to the level of the 7th lumbar vertebra for aseptic surgery. Palpating the transverse process (left, L2 and L3; right, T13 and L1), a 3 cm incision was made between the transverse process of each palpated vertebra. Electrocautery was used for hemostasis to prevent hemorrhage after the skin incision was

made with a scalpel blade. Blunt dissection with Metzenbaum scissors and the index finger positioned below the epaxial muscle was used to access the retroperitoneal space through the muscle structures (external oblique, internal oblique, and transverse abdominal). Ability to palpate the ventral aspect of the kidney indicated successful entry into the retroperitoneal space after dissection of the thoracolumbar fascia. A SILS port (Covidien, New Haven, CT, USA) was placed using a stay suture for retraction of the skin and muscles. After placing three 5 mm cannulas for triangulation of the laparoscopic instruments, the retroperitoneal space was investigated with a 5 mm, 0° telescope (Karl Storz, Tuttlingen, Germany). When the retroperitoneal space was visualized, pneumoretroperitoneum was induced using an insufflator (Karl Storz) at 5–mmHg pressure.

Left Adrenalectomy

The telescope was introduced into the retroperitoneal space via the middle cannula. The other cannulas were used for insertion of Kelly forceps (Karl Storz) and a vessel-sealing device (LigaSure™ 5 mm sealer and divider connected to a LigaSure or Force Triad™ generator; Covidien, Mansfield, MA, USA) as shown in Fig. 1. Initially, the fascia and fat tissue was dissected delicately using the telescope, resulting in exposure of the retroperitoneal structures, i.e., the kidney, renal vessels, phrenicoabdominal vein, and adrenal gland (Fig. 2). Taking care not to damage the left renal vein, the periadrenal gland tissue at the caudal

aspect was dissected first before dissecting the medial aspect of the left periadrenal gland for circumferential dissection. This enabled the periadrenal tissue to be held steady while the adrenal gland was retracted (Fig. 3). During dissection of the caudal and medial aspects, the phrenicoabdominal vein running through the middle of the adrenal gland was isolated by dissection of adjacent tissue and transected with the help of the LigaSure. The cranial pole of the gland was surrounded with retroperitoneum, to which the visceral adrenal capsule was attached. Because of these anatomic features, the cranial retroperitoneum, including the cranial surface of the gland, was dissected together with the visceral adrenal capsule. After dissecting the cranial aspects of adrenal gland, the ventral aspect of the adrenal gland was dissected. The excised adrenal gland was removed through the incision line (Fig. 4).

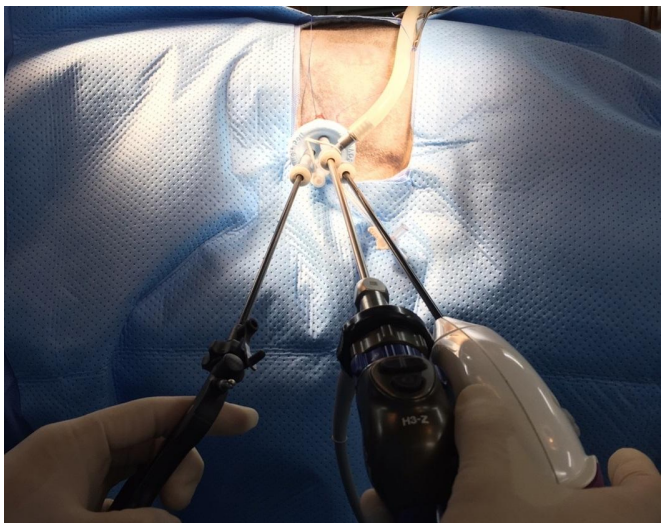

Figure 1. Single port placement via a SILS port in left retroperitoneoscopic adrenalectomy. Each of the instruments was introduced through three cannulas.

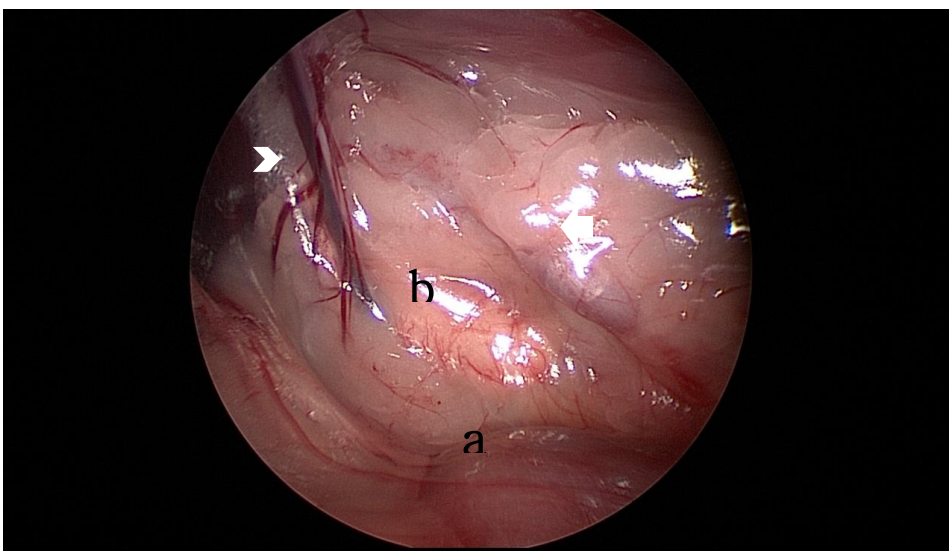

Figure 2 Left retroperitoneoscopic approach. After dissection of fatty tissue in the retroperitoneal space, the retroperitoneal organs were seen directly: a, left kidney, b, left adrenal gland. Arrow indicates the renal vessels. Arrowhead indicates the phrenicoabdominal vein

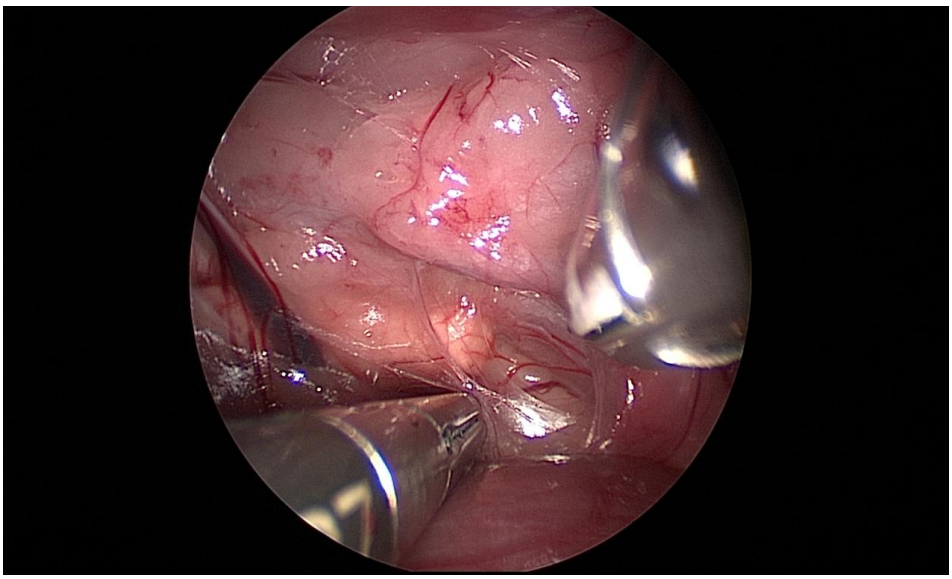

Figure 3 Left retroperitoneoscopic adrenalectomy. The caudal aspect of the left adrenal gland was dissected first. The branches of the phrenicoabdominal artery flowed into the adrenal gland.

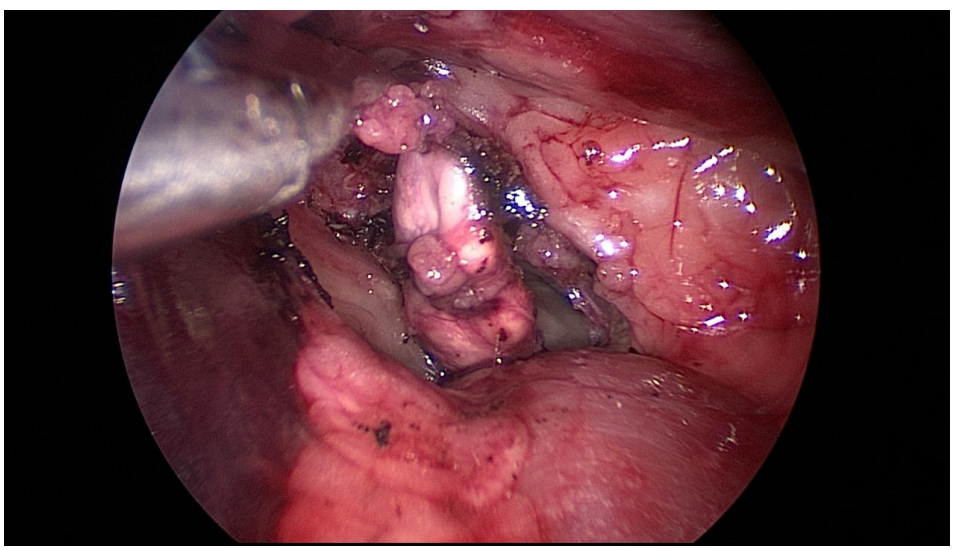

Figure 4 The retroperitoneal space before removal of the left adrenal gland. The gland was grasped by Kelly forceps. To prevent damage to the adrenal gland, the periadrenal tissue was gripped for retraction of the gland.

Right Adrenalectomy

After placement of the SILS port, the fascia and fat tissue were dissected under telescopic guidance via the middle cannula of the port (Fig. 5). The right renal vessels were located laterally and were connected to the right kidney. The phrenicoabdominal artery and vein located at the region cranial to the right renal vessels were transected at the point proximal to the branches, many of which extended to the periadrenal tissues. The distance between the caudal pole of the right adrenal gland and the renal vein was longer than that between the left adrenal gland and the renal vein. After dissection of the caudal aspect of the periadrenal tissue, the tissue was grasped by Kelly forceps for retraction of the adrenal gland. The medial and cranial aspects of the adrenal gland were dissected, exposing the caudal vena cava on the ventral surface of the gland. Upon retraction of the adrenal gland in the dorsal direction, the gland was separated from the caudal vena cava but was still connected to this vessel by the gland capsule (Fig. 6). After dissection from the caudal vena cava, the right adrenal gland was resected completely (Fig. 7).

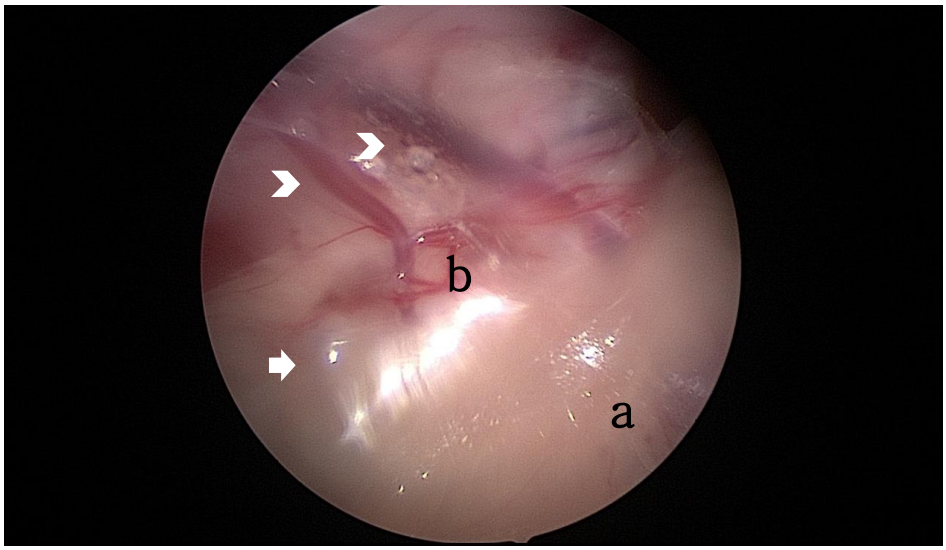

Figure 5 Right retroperitoneoscopic approach. Unlike the left retroperitoneoscopic approach, the phrenicoabdominal artery is distinguished clearly a, right kidney; b, right adrenal gland. Arrow indicates the renal vessels. Arrowhead indicates the phrenicoabdominal vessels.

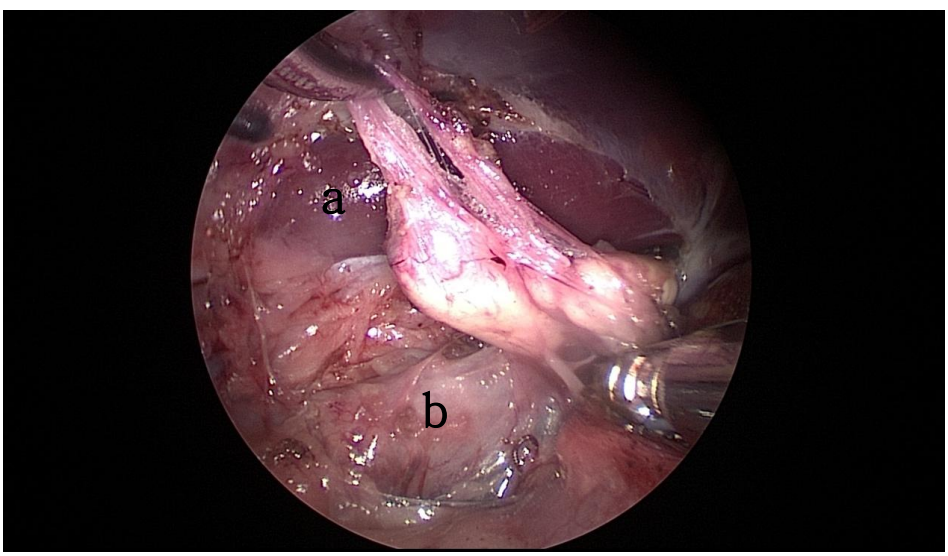

Figure 6 Right retroperitoneoscopic adrenalectomy. Finally, the LigaSure is used to dissect the capsule of the gland from the caudal vena cava. a, epaxial muscle; b, caudal vena cava

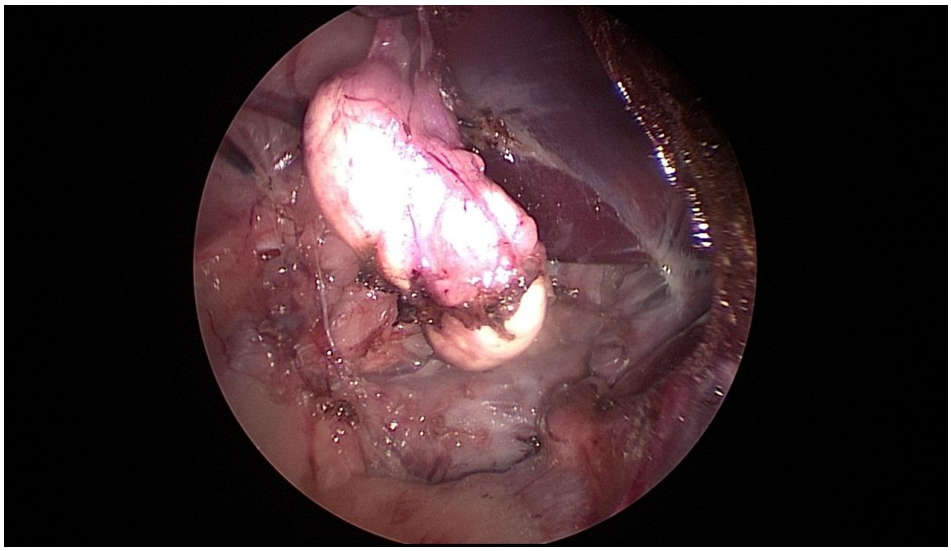

Figure 7 View of the right adrenal gland after all aspects were dissected. None of the injuries was on the caudal vena cava. Hemorrhage seldom occurred in the retroperitoneal space during resection.

Closure

The external oblique, internal oblique, and transverse abdominal muscles were sutured together. The subcutaneous suturing was completed using a simple continuous pattern and the skin was sutured using a simple interrupted pattern. The operation time was measured from the point of making the incision to closure of the surgical wound.

Postoperative Care

On closing the incision, local anesthetic infiltration was provided in the operative area using a mixture of bupivacaine 0.2 mg/kg and lidocaine 1.6

mg/kg. An oral antibiotic (cephalexin 22 mg/kg twice daily) and oral analgesics (tramadol 5 mg/kg twice daily, meloxicam 0.1 mg/kg once daily) were administered for 7 days after SPRA.

Assessments of Postoperative Pain

Pain was assessed on recovery from anesthesia and on postoperative days 3, 7, and 14. Three scoring methods were used to assess the pain associated with SPRA. The first method was the Numerical Rating Scale that scores items such as demeanor (0–4), movement (0–2), appearance (0–3), behavior (0–3), interactive behavior (0–3), vocalization (0–3), heart rate (0–3), and respiration rate (0–3). (Firth and Haldane, 1999, Gaynor and Muir, 2014, Devitt *et al.*, 2005, Walsh *et al.*, 1999, Hellyer and Gaynor, 1998) The maximum possible score is 24, with 0–8 indicating mild pain, 9–16 indicating moderate pain, and 17–24 indicating severe pain. The second method was the University of Melbourne Pain Scale, which scores physiologic data (0–11), response to palpation (0–3), activity (0–3), mental status (0–3), posture (0–4) and vocalization (0–3). (Gaynor and Muir, 2014, Hancock *et al.*, 2005) This scale also scores the severity of pain as mild (0–9), moderate (10–18), or severe (19–27). The third method was the Colorado State University Veterinary Medical Center Canine Acute Pain Scale which scores psychological and behavioral items, response to palpation, and body tension. (Gaynor and Muir, 2014) Each of the three dimensions is measured on a 4−point pain

scale (0, none; 1, mild; 2, moderate; 3, severe). A mean pain score above moderate indicates the need for additional analgesia.

Histologic assessments

After thickness of the adrenal glands at the cranial and caudal poles was evaluated, the excised adrenal glands were stored in specimen cups with 10% neutral formalin. The tissue fixation time was more than 48 h. Fixed samples were dehydrated before being embedded in paraffin. The samples were divided at this time into four pieces for precise evaluation of damage to the capsule. The paraffin blocks were sliced in 5-μm-thick sections. All slides were stained using hematoxylin-eosin. The capsule of each excised adrenal gland was assessed for surgical damage.

Statistical Analysis

All data were analyzed using SPSS Statistics version 23 software (IBM Corp., Armonk, NY, USA). The statistical significance of differences in operation and port placement times between the left and right approaches was evaluated using the Student's t-test.

III. Results

Operation Time

The mean (± standard deviation) operation time was 44.1 ± 6.1 (range 37–51) min for retroperitoneoscopic adrenalectomy, 49.3 ± 1.5 (range 48–51) min for right SPRA, and 38.5 ± 1.29 (range 37–40) min for left SPRA (Table 1). The operation time for right SPRA was significantly longer than for left SPRA ($P < .05$). (Naan *et al.*, 2013, Jiménez *et al.*, 2008) The difference in mean port placement time (9.8 ± 1.36 min; range 8–12 min) between the left and right approaches was not significant.

Table 1 Surgical details of retroperitoneoscopic adrenalectomy in this study

Dog	Site	Operation time (min)	Cranial pole (mm)	Caudal pole (mm)
1	Left	40	10	11

2	Left	37	7	8
3	Left	38	11	7
4	Left	39	8	7
5	Right	48	10	9
6	Right	50	10	5
7	Right	48	12	8
8	Right	51	12	6

Outcome

All SILS ports were placed successfully. The adrenal gland was approached directly and easily excised without manipulation of other organs. Conversion of adrenalectomy to laparotomy was unnecessary, and no severe bleeding events occurred. There were no instances of injury to adjacent tissue. Most dogs adopted a standing position and were walking around within 30 min of extubation. There were no postoperative complications such as port site hemorrhage, hematoma, dehiscence, or seroma.

Assessment of Postoperative Pain

Mean scores on the Numerical Rating Scale, University of Melbourne Pain Scale, and Colorado State University Veterinary Medical Center Canine Acute Pain Scale were <9, <10, and <2, respectively (5/24,

6.5/27, and 0.75/4, respectively, for the left; 5.75/24, 7/27, and 0.92/4 for the right), indicating that postoperative pain upon recovery from anesthesia was mild. Lower pain scores were recorded for all dogs on days 3, 7, and 14 after surgery (Table 2).

Histologic Assessment

The mean thickness of the cranial pole was 1 ± 0.18 (range, 0.7–1.2) cm and that of the caudal pole was 0.76 ± 0.18 (range, 0.5–1.1) cm (Table 1). Three adrenal gland capsules were found to have sustained surgical damage on slides stained with hematoxylin–eosin. The injuries were limited to small defects in the capsule. The adrenal parenchyma, including the cortex and medulla, was unaffected in all cases.

Table 2 Postoperative pain assessment after retroperitoneoscopic adrenalectomy

	Post-op	Day 3	Day 7	Day 14
Numerical Rating Scale (0-24)				
Left	5 (1.83)	2.26 (0.96)	1.25 (0.5)	1 (0)
Right	5.75 (1.26)	2.5 (0.58)	1.25 (0.5)	1 (0)
University of Melbourne Pain Scale (0-27)				
Left	6.5 (2.38)	4 (2.45)	2.5 (1)	2 (0)

Right	7 (0.82)	4.75 (0.5)	2.5 (1)	2 (0)
Colorado State University Veterinary Medical Center Canine Acute Pain Scale (0-4)				
Left	0.75 (0.5)	0.58 (0.32)	0.08 (0.17)	0 (0)
Right	0.92 (0.92)	0.67 (0.32)	0.16 (0.19)	0 (0)

*Mean values (standard deviation)

IV. Discussion

Both right-sided and left-sided adrenalectomy procedures were feasible using SPRA in this study. In previous studies, multi-port laparoscopy has been used to perform adrenalectomy in dogs. (Naan *et al.*, 2013, Jiménez *et al.*, 2008) Although the method described by Naan *et al.* achieved a better outcome than conventional methods, their procedure included placement of 3 ports, and thus, it was still multi-port laparoscopic surgery. (Naan *et al.*, 2013) Moreover, it is necessary to retract other organs to expose an adrenal gland tumor, despite the effect of gravity displacing some abdominal organs in sternal recumbency and providing good visibility. (Naan *et al.*, 2013, Jiménez *et al.*, 2008) Shorter hospital stays and less severe pain responses have been reported using a

single-port method rather than a multi-port method for retroperitoneoscopic adrenalectomy in humans. (Walz *et al.*, 2010) In this study, the single port method maximizes the minimally invasive effect via a retroperitoneal approach to adrenalectomy without retracting other organs and provides direct access and marvelous view of the adrenal gland, which is not possible with transperitoneal laparoscopy.

Retroperitoneoscopic Approach for Adrenalectomy

The human retroperitoneum can be divided into two anatomic regions, i.e., anterior and posterior). However, posterior retroperitoneoscopic adrenalectomy has been preferred to be performed in humans. (Lee *et al.*, 2012, Callender *et al.*, 2009, Berber *et al.*, 2009, Perrier *et al.*, 2008, Walz *et al.*, 2008, Darzi, 1996) This surgical method is advantageous in humans because it does not require entry into the peritoneal cavity and, unlike transperitoneal laparoscopic surgery, does not come with the risk of postoperative adhesions. (Callender *et al.*, 2009, Berber *et al.*, 2009) In addition, there is no requirement to reposition patients as for bilateral adrenalectomy in a sternal position. Unlike in humans, the anatomic structure of the dog cannot be divided into anterior and posterior regions

(known as the ventral and dorsal regions in dogs). I considered that an approach could be developed for dogs using the posterior retroperitoneum in humans as a reference, since it is known from previous research that the retroperitoneal area in the dog is similar in form to that of the human posterior retroperitoneum. (Johnston *et al.*, 1990)

For retroperitoneoscopic adrenalectomy, the landmark for access into the retroperitoneal space is the tip of the 12th rib in humans, but the equivalent landmark has not been reported in dogs. (Walz *et al.*, 2001, Walz *et al.*, 1996, Walz *et al.*, 1998, Lee *et al.*, 2012, Callender *et al.*, 2009, Gockel *et al.*, 2005, Berber *et al.*, 2009, Perrier *et al.*, 2008, Walz *et al.*, 2008, Shonkwiler *et al.*, 2011, Walz *et al.*, 2006, Barczyński *et al.*, 2007) I felt that it was possible to approach the retroperitoneum using the transverse processes of a vertebra as the landmark. Correct initial placement of the port is important when accessing the retroperitoneal space. Once the retroperitoneal approach has failed during surgery, pneumoperitoneum makes it difficult to re-approach the retroperitoneum because of its effect on the location of the retroperitoneal organs. Since it is difficult to explore the exact location of the retroperitoneum, I used an approach that entailed blind palpation with a finger and blunt dissection for port placement at the level of T13 and L3, which is similar

to the approach for open retroperitoneal adrenalectomy reported for both humans and dogs. (Walz *et al.*, 2001, Walz *et al.*, 1998, Johnston *et al.*, 1977) The left adrenal gland and right adrenal gland are located at L2 and T13, respectively. Accordingly, L2-L3 for left adrenalectomy and T13-L1 for right adrenalectomy were considered to be appropriate locations from which to make an approach. After the external oblique, internal oblique, and transverse abdominal muscles were dissected, the thoracolumbar fascia forming the parietal retroperitoneum was palpated. Penetration of this fascia led to palpation of the kidneys, which means the approach to retroperitoneum. To prevent carbon dioxide leakage, a blunt tip trocar with balloon applied in the previous study (Jeong *et al.*, 2016) is used in humans because retroperitoneal approach is an open-entry technique. (Walz *et al.*, 1998, Callender *et al.*, 2009, Perrier *et al.*, 2008, Walz *et al.*, 2006, Barczyński *et al.*, 2007) In humans, two additional ports are placed after the trocar to approach the adrenal gland. Unlike in humans, setting of the landmarks for additional ports is difficult in dogs because the ventral part of the retroperitoneum is not attached to the transverse abdominal muscle, so insertion of additional ports is both challenging and time-consuming. Therefore, I elected to use a single port approach through a small 3 cm incision in this study. Since the flexible single port can secure the thoracolumbar fascia, which is in the

deepest part of the retroperitoneum, it was possible to maintain inflation of the retroperitoneal space without leakage of gas as occurs with a blunt tip trocar. Moreover, the single port technique may shorten the operation time by not requiring placement of additional ports.

Anatomic Structures

With this approach, I observed soft fatty tissues similar to those of the Gerota' s fascia in humans. (Callender *et al.*, 2009) This fatty tissue can be removed simply using telescope guidance just as in humans, and upon dissection, the adipose tissues surrounding the various organs in the retroperitoneoscopic area were visible. Once the adipose tissues were dissected, the contours of each organ could be precisely viewed. The first landmark that should be identified when locating the adrenal gland is the kidney, which is found at the ventrocaudal part in the view. The adrenal gland was located by dissecting the cranial side of the renal vessel where the vessels runs in the mediodorsal direction from the kidneys. There was no need to pull or manipulate the other organs while isolating the adrenal gland. The second landmark to identify when locating the adrenal gland is the phrenicoabdominal vein, which runs through the middle part of the adrenal gland between the cranial and caudal poles of the gland. In the right-sided approach, the

phrenicoabdominal artery is clearly distinguished but not so with the left-sided approach. For the transection, a vessel-sealing device was used to separate the tissues around the adrenal gland. The epaxial muscle was found in the mediodorsal area; upon resection of the adrenal gland, the caudal vena cava, to which the capsule of adrenal gland was connected, was found on the ventral aspect of the adrenal gland.

Dissection

For a right adrenalectomy, retroperitoneoscopy has the advantage of good visibility of the capsule connected to the caudal vena cava, which can reduce the risk of damage to this vessel. Unlike on the right side, the ventral aspect of left adrenal gland is connected to the peritoneum and can be dissected easily. This took a relatively shorter time for left adrenalectomy than for right adrenalectomy. As reported in humans (Walz *et al.*, 2001, Barczyński *et al.*, 2007), neither right nor left retroperitoneoscopic adrenalectomy requires preparation of the abdominal organs, which might decrease complications such as pancreatitis, intestinal obstruction, and adhesions.

The cranial part of both adrenal glands is attached to the peritoneum. The peritoneum should be dissected completely so that the cranial side can be examined thoroughly before resection. Otherwise, it is impossible to secure a view of the cranial side. Poor visibility may cause bleeding and make complete resection impossible. The retroperitoneal and peritoneal cavities may be connected since a hole is created in the peritoneum. However, even if both cavities are connected, the view is not obstructed regardless of whether left adrenalectomy or right adrenalectomy is performed because inflation of the peritoneal cavity does not put pressure on the retroperitoneal cavity.

Manipulation of Instruments

When SPRA was first performed in humans, the large vessels were tied using an endoscopic hemoclip. (Walz *et al.*, 2001, Walz *et al.*, 1996, Walz *et al.*, 1998, Walz *et al.*, 2006, Barczyński *et al.*, 2007) The LigaSure is regarded as a better method for sealing and dividing vessels because it reduces the surgery time. (Lee *et al.*, 2012, Walz *et al.*, 2008) In humans, the adrenal gland is connected to the inferior, middle, and superior adrenal arteries and veins. (Callender *et al.*, 2009, Shonkwiler *et al.*, 2011, Standing, 1996) However, in dogs, the adrenal artery is connected to a number of branches of the phrenicoabdominal artery, so dissection of the periadrenal tissues is likely to cause arterial bleeding.

(Evans and de Lahunta, 2012) This problem can be easily overcome if the LigaSure is used for dissection and hemostasis.

The disadvantage of the single port is that the instruments may collide with each other, which is common in the small working space involved in the retroperitoneoscopic approach. However, the SILS port consists of flexible material that allows a large degree of freedom to manipulate laparoscopic instruments. Further, the resection might not be difficult for a surgeon with laparoscopic experience. Although I used non-articulated surgical instruments, this surgery may be even more effective if performed using articulated instruments, which could be manipulated more comfortably.

Outcome

In this study, there were no problems like subcutaneous emphysema, hematoma, hernia, dehiscence, or hemorrhage, that are likely to occur in the port area after this type of surgical procedure. (Callender *et al.*, 2009, Walz *et al.*, 2008) Substantial hemorrhage, which is a possible complication during the surgery, would not occur if the renal vessels, aorta, and caudal vena cava are securely separated in the approach and during resection of the adrenal gland. If severe bleeding occurs,

conversion to open surgery will be needed but should not affect the outcome for the patient. (Chiang *et al.*, 2015)

Postoperative Pain

In contrast with multi-port laparoscopic surgery, there are some reports in humans suggesting that SPRA is less painful, requires a shorter hospital stay, and has cosmetic benefits. (Walz *et al.*, 2010, Beiša *et al.*, 2012, Joseph and Patel, 2011, Beiša *et al.*, 2011) In one of these studies, visual analogue pain scale scores suggested that pain after single-port retroperitoneoscopic surgery was less severe than that after transperitoneal laparoscopic surgery. (Joseph and Patel, 2011) When I palpated the surgical site in the postoperative period, some dogs did not show a marked pain response, such as guarding the wound site or aggressive behavior. In this study, a mild pain response was observed in all dogs using three different pain assessment methods postoperatively. This indicates that pain levels were manageable. However, transient and mild pain was present in the short term.

Resected Adrenal Gland Tissues

In humans, the indications for posterior retroperitoneoscopic adrenalectomy and transperitoneal adrenalectomy are limited to benign

tumors. Further, a resectable adrenal gland size limit of 6 cm is specified. (Callender *et al.*, 2009) However, in dogs, a clinical study is needed to determine the size limit for resection. Taking the 3-cm incision used in the present study as a guide, tumors up to 3 cm in size could be removed through the incision line and SPRA may be limited to benign tumors (e.g., incidentalomas and adenomas).

Damage to the capsule seemed to be mild in this study, though this may not be the case in excision of an adrenal tumor. Spillage of tumor cells via a damaged capsule can occur in laparoscopic adrenalectomy, leading to peritoneal carcinosis. (Mayhew *et al.*, 2014, Jiménez *et al.*, 2008, Walz *et al.*, 2001, Van Sluijs *et al.*, 1995) Retroperitoneoscopic surgery might reduce the risk of tumor cells seeding to the abdominal organs because the retroperitoneal space is separated from the peritoneal space, comparing with transperitoneal laparoscopic adrenalectomy.

This study demonstrated that SPRA is feasible in dogs. However, this research does have some limitations. First, although the surgery did not affect any laboratory measurements (complete blood count, serum chemistry, electrolytes) during the preoperative and postoperative periods, my study did not include an investigation of clinical safety or any aspects of clinical application. Second, the study population did not

include various sizes and breeds of dogs. Third, I did not compare retroperitoneoscopic adrenalectomy with other techniques used to perform adrenalectomy. Fourth, the number of dogs included in the study was too small to evaluate the outcome of SPRA. However, of the minimally invasive techniques used to perform adrenalectomy in dogs, SPRA would be a preferable option because it is a direct approach that enables resection of the adrenal gland without any need to retract the other organs, unlike with conventional adrenalectomy. In addition, postoperative pain levels were relatively mild after SPRA, which would be beneficial in the clinical setting. Future studies should compare the clinical benefits of SPRA in dogs in comparison with conventional surgery methods.

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VI. Abstract in Korean

개에서의 단일통로후복강경 부신절제술

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복강경 부신절제술은 부신절제술에 대한 최신의 최소침습수술로써, 수의학에서도 이에 대한 연구가 활발히 진행되고 있다. 사람에서는 부신의 위치가 후복강인 것에 착안하여, 복강경 수술뿐만 아니라, 후복강경 수술을 사용하고 있으며, 그에 따른 임상적 결과는 다양하다. 그래서 이번 연구는 개에서의 후복강경 부신절제술의 고안과 단일통로후복강경의 실현 가능성을 평가하는 것에 목적이 있다. 8마리의 실험 비글견에서 단일통로후복강경 부신절제술을 좌측 부신과 우측 부신, 각각 4마리씩 실시하였다. 후복강 접근을 위해 3 cm의 절개선을 만들고 단일통로 (SILS port)를 이용해 후복강경을 장착 후, 부신을 절제하였다. 술 후 통증 정도는 Numerical Rating Scale, University of Melbourne Pain Scale, Colorado State University Veterinary Medical Center Canine Acute Pain Scale을 이용하여 평가하였고, 수술 중 부신 껍질에 생길 수 있는 손상은 조직학적 평가를 통해 측정하였다. 후복강 내로 접근

하자마자, 다른 장기의 견인 없이 지방 조직 분리 후에 바로 부신이 시야에서 확인되었다. 단일통로후복강경 부신절제술은 평균 44.1분 (37-51분) 소요되었으며, 우측 (평균 49.3분)이 좌측 (평균 38.5분)보다 시간이 더 소요되었다. ($P < .05$) 술 중, 술 후 14일 동안 복합증은 발생하지 않았고, 술 후 통증에 대해 적절한 진통 관리가 실시되었다. 부신의 조직학적 손상은 부신 껍질에 한하여 8마리 중 3마리에서 미약한 손상을 보였다. 이번 연구를 통해 다른 복강 장기의 견인 없이 바로 부신 절제술을 실시할 수 있을 것으로 사료된다.

주요어 : 개, 후복강경, 부신절제술, 후복강경 부신절제술, 단일통로 복강경, 최소침습수술

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